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EARTH SCIENCES WASTE DISPOSAL MONITORING ACTIVITIES
MARCH, 1955

By

R. E. Brown
K. R. Holtzinger
J. R. Raymond

Earth Sciences Unit
Radiological Sciences Department

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INTRODUCTION

The increase in number and variety of liquid radioactive waste streams and the increasing volumes of liquid wastes routinely discharged to ground recommend constant appraisal of the factors permitting such disposal and regular detailed reporting of actions pertinent to that appraisal.

The Earth Sciences Unit is instituting with this report a monthly summary detailing its Protection of Plant and Personnel activities and the most closely related and supporting Research and Development studies.

Summaries of the average activity densities encountered in the ground waters in January and February in wells sampled by Earth Sciences at sites of disposal of radioactive wastes are listed for reference data. Experience has shown that trends and their significance are seldom apparent in less than three months; fluctuations in the average values reported should be viewed on that basis. Succeeding report will list the apparent changes or trends of the activity densities, as compared to those of the previous report period.

SUMMARY OF ANALYSES AND EVALUATION

Two hundred twelve routine samples of ground water were taken by Earth Sciences personnel from wells in March and were analyzed by the Radio-Analysis Laboratory, using standard radiochemical procedures. Activity densities were calculated by Radiation Measurement Evaluation. This number of samples compared to 200 samples taken in February and 196 in January. Five routine sediment samples were taken in March compared to nine each in January and February. Thirty-nine of the wells to water were sampled during March for non-radioactive sodium and nitrate ion analyses. These ions have proved highly valuable as "leaders" or "tracers", indicate the direction of movement of the ground water and the contained radioisotopes, and provide a means of further confirming the absence or presence of contamination by the radioisotopes.

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300 NORTH AREA

321 Building Crib Site (for Location See Brown, Raymond, and McConiga (1)

TABLE I

Well No.	ACTIVITY DENSITIES: Alpha Emitter Units of 10^{-9} uc/cc March	February	January	Beta-Gamma Emitter Units of 10^{-8} uc/cc March	February	January	Non-Radioactive Ions (PPM) March Na^+	NO_3^-
321-2	2.7	3.2	2.7	2.5	1.5	1.5	20	2.8
321-4	2.0	4.7	2.9	5.0	3.0	6.0	22	1.4
321-5	29.7	30.4	24.3	3.0	2.0	3.0	27	39.4
321-6	34.2	36.2	37.1	3.2	5.2	1.0	25.5	20.7
321-7	2.5	3.8	3.4	2.0	3.0	3.0	25	30.3
321-8	6.3	9.0	6.1	2.4	2.0	3.0	26.5	32.9
321-9	1.1	1.0	1.8	3.8	2.5	4.5	26	3.4

The southeastward movement of the alpha emitters (uranium) in the ground water from the site of well 321-1, monitored and sampled by Regional Monitoring, and toward wells 5, 6. 7, 8, and 9 averages about 25 feet per month. Wells 2, 4, and 9 show activity densities comparable to those reported as background densities by Brown and Ruppert (2). The location of wells 2 and 4 east of the source of contamination and nearly 60 degrees from the path of confirmed contamination further suggests that the indicated densities are background levels. Contamination of the ground water by radioisotopes is confirmed by the significantly higher nitrate ion concentrations in the water in wells 5, 6, 7, and 8 but sodium ions are not demonstrably present in the contaminated wells in amounts above what regional studies have shown are the natural concentrations.

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200 EAST AREA

241-B-361 Reverse Well Site and 5-6 Crib and Tile Field Site (For Location of Wells see Brown and Ruppert (2)

TABLE II

ACTIVITY DENSITIES

Well No.	Alpha Emitter Units of 10^{-9} uc/cc			Beta-Gamma Emitter Units of 10^{-8} uc/cc		
	March	February	January	March	February	January
361-B-1	11	8.6	13.3	2.7	3.2	6.4
361-B-4	0.4	0.1	0.5	7.7	7.4	7.3
361-B-5	1.6	0.5	0.5	5.5	6.2	10.7
361-B-7	1.3	1.0	--	16	19	19
361-B-9	1.9	3.8	1.9	5.5	5.6	2.6

Contamination of the ground water at this site resulted from use of the 241-B-361 reverse well, which well was removed from service in November, 1947. Routine monitoring since that date has resulted in the accumulation of considerable data bearing on and guiding waste disposal operations, as outlined by Brown and Ruppert (2) and by Brown, Raymond and McConiga (1). The presence of significant amounts of beta-gamma emitters in wells 361-B-4, 5, and 7, essentially at background levels for the alpha emitters, indicates a slow eastward movement from the vicinity of the reverse well and wells 361-B-1 and 9, now essentially at background levels for the beta-gamma emitters. This is presumably due to the influence of the rising 200 West area ground water mound, the lowering 200 East area mound, and the consequent eastward movement toward an equilibrium balance. The extremely low concentration of non-radioactive salts in the 5-6 wastes discharged to the site precludes the use of the ions used advantageously elsewhere.

Sediment samples are routinely taken from the bottoms of test holes 5-6 #1, 3, and 4 in the 5-6 tile field. These test holes bottom at the tile field level. The crib and tile field, long out of regular service, provide a facility at which the variance in activity densities, due to variance in the sediment composition, can be determined. The activity densities on the sediments are as follows:

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TABLE III

Well No.	Beta-Gamma Emitter Activity Density 10^{-3} uc/g March	February	January
5-6 #1	0.89	0.95	1.50
5-6 #3	0.19	0.27	0.34
5-6 #4	0.16	0.16	0.18

241-B 2nd Cycle Crib Site (For Locations of wells, see Brown and Ruppert (2), and Brown, Raymond, and McConiga (1).

TABLE IV

	ACTIVITY DENSITIES						Non-Radioactive Ions (PPM)	
	Alpha Emitters Units of 10^{-9} uc/cc			Beta-Gamma Emitters Units of 10^{-8} uc/cc			Na^+	NO_3^-
Well No.	March	February	January	March	February	January	March	
224-B-4	5.0	5.9	2.9	16	7.0	15	200	1250
241-B-5	--	5.3	3.4	560	980	710	>1000	7580
241-B-11	8.1	5.0	3.8	2154	1217	465	>1000	5440
241-B-15	4.1	1.9	2.3	12	4.5	2.5	10.5	<1
241-B-16	4.1	3.6	3.6	1125	1050	600	>1000	6640
241-B-17	5.4	3.0	3.8	6	3	2	24	7.6
241-B-18	2.0	0.5	1.0	7.2	6.7	5.7	60	<1
241-B-19	1.0	1.9	1.0	7.0	5.4	2.2	40	<1

241-BY (TBP) Crib Site, 241-BX First Cycle Trenches

TABLE V

	ACTIVITY DENSITIES						Non-Radioactive Ions (PPM)	
	Alpha Emitters Units of 10^{-9} uc/cc			Beta-Gamma Emitters Units of 10^{-8} uc/cc			Na^+	NO_3^-
Well No.	March	February	January	March	February	January	March	
241-BY-2	--	--	5.0	--	--	1	58	139
241-BY-8	--	1	1	8.5	11.5	6	22.5	<1
241-BY-9	3.7	2.7	1.4	15.2	15.5	4	24	2.2
241-BY-10	(Well plugged by Drilling Equipment)							
241-BY-11	2.9	2.2	2.1	8.2	3	2.7	22	2.3
241-BY-12	--	1.2	2.3	23	9.6	4.2	20	<1

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The increase in the concentration of beta-gamma emitters, above presumed background levels, (See Brown and Ruppert (2), in wells 241-B-11 and 16, parallels an increase in non-radioactive salts and suggests penetration to the ground water of TBP "bottoms" stored in the 110-111-112-B tank cascade and presumably carried into the 2nd cycle crib by wash waters released from the B-plant. The indicated slight rise in beta-gamma emitter density in wells 241-B-15 and 17, northwest of the crib, suggests a possible spreading of the contaminated zone in that direction toward the 241-BY (TBP) cribs. Wells adjacent to and near the 241-BY cribs show possible contamination by beta-gamma emitters, which contamination is not confirmed to date by the non-radioactive salts, as indicated previously.

The suggested presence of comparable amounts of beta-gamma emitters above presumed background levels in the water in the 241-BY-8 well, the first-cycle trenches monitoring well, and in the three of the four TBP crib wells, 241-BY-9, 11, and 12, suggests a more general source for the contamination, if it can be confirmed, than might result from contamination of the ground water by wastes from one of the TBP cribs used to date. Only the first three TBP cribs have been used, opposite wells 9, 10, and 11, yet indicated comparable rises were present in the water in wells 241-BY-8 and 12. Verification of contamination and determination of its exact source, whether from one of the 241-BY (TBP) cribs or from the 2nd cycle crib, must await further sampling and evaluation of data. Well 241-BY-2 lies within the 241-BY tank farm, appreciably nearer the 2nd cycle crib than the remaining 241-BY wells to water.

Removal of the 241-B 2nd cycle crib from service is recommended on the basis of the presence of the TBP bottoms in the 110-111-112-B tank cascade, on the proposed reactivation of the B-plant, and on the undesirability of further contaminating the ground water at this site with radioisotopes.

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200 WEST AREA

241-T-361 Reverse Well Site (For Well Locations See Brown, Raymond and McConiga (1)

TABLE VI

Well No.	Alpha Emitters Units of 10^{-9} uc/cc March	February	January	Beta-Gamma Emitters Units of 10^{-8} uc/cc March	February	January	Non-Radioactive Ions (PPM) March Na^+	NO_3^-
241-T-361	1.8	1.4	2.3	4.5	1.5	1.7	92	58
361-T-12	1.0	1.0	1.1	4.1	6.1	1.2	47	14.5
361-T-14	3.4	1.9	2.1	4.8	3.6	3.1	15	148
361-T-15	1.6	0.4	0.9	7.6	11	6.9	22.5	232
361-T-16	5.2	4.7	6.6	12.0	11.5	9.0	39.5	400
361-T-17	6.3	5.0	4.4	58	--	62.7	170	2060
361-T-18	4.1	3.3	2.5	34	33	34.5	92	1420
361-T-19	2.0	2.9	1.7	6.1	4	2.6	150	63
361-T-22	1.6	2.5	0.8	5.7	14	8.2	15.5	90

The lack of almost all change in concentration of radioisotopes in these wells is attributed to the slow rate of movement of the ground water at this site, even under the increased gradient resulting from use of the 200-West area swamps. An average rate of travel, based on the progress of nitrate ion, is about 20 feet per month since contamination of the ground water first occurred, as noted by Brown, Raymond, and McConiga (1).

241-T 2nd Cycle Crib and Tile Field Site (For Well Locations see Brown and Ruppert (5) and Brown, Raymond and McConiga (1)

TABLE VII

Well No.	Alpha Emitters Units of 10^{-9} uc/cc March	February	January	Beta-Gamma Emitters Units of 10^{-8} uc/cc March	February	January	Non-Radioactive Ions (PPM) March Na^+	NO_3^-
224-T-4	--	1.0	0.3	3.0	6.8	1.5	8.3	1.0
224-T-10	20	1.6	1.9	2700	1450	1350	>1000	15200
241-T-15	3.6	5.0	4.5	6.0	5.9	10	140	600

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TABLE VII (Cont.)

Well No.	ACTIVITY DENSITIES: Alpha Emitters, Units of 10^{-9} uc/cc			Beta-Gamma Emitters, Units of 10^{-8} uc/cc			Non-Radioactive Ions (PPM), March	
	March	February	January	March	February	January	Na^+	NO_3
241-T-16	12.2	13.4	8.9	272	120	47	100	5600
241-T-17	2.1	13.3	16.1	390	350	458	420	3020
241-T-18	1.0	1.4	2.6	18	20.7	8	9.5	160
241-T-19	0.4	0.4	1.0	19.3	13.5	17.2	21	310
241-T-20	0.5	1.2	1.0	22.0	10.6	14.6	17	122
241-T-21	1.0	1.2	1.0	9.8	9.3	3.5	10	14.3
231-2	0.4	1.0	0.3	13.5	8.0	4.4	9.5	2.0

Sediment samples from well 241-T-1, bottoming 20 feet beneath the 241-T 2nd cycle crib gave the following results:

Well No.	Beta-Gamma Emitter Density 10^{-3} uc/g: March	February	January
241-T-1 (46' depth)	12.9	18.7	25.2

The build-up of Cs on the sediments at this sampling point and the appearance of trace amounts in well 224-T-9, at a depth of about 80 feet and about 100 feet southwest of the crib, provides information on the rate of progression of the Cs front in the direction of indicated movement of the waste liquids above the water table. Samples were not analyzed for Cs during the report period.

Continued use of the 241-T 2nd cycle crib has resulted in the breakthrough of significant amounts of beta-gamma emitters to well 224-T-10. Installation of a new crib was recommended by Radiological Engineering (3) on the basis of data reported by Earth Sciences including the rising activity density in the ground water in this well, the decreased percolation rate in the crib and tile field which indicates a physical sealing of the ground at that facility, and on the indicated penetration of Cs to at least a depth of 100 feet from the ground water table as indicated by Rhodes (4).

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Westward movement of the contaminated water was noted by the appearance of non-radioactive nitrate ions and apparently beta-gamma contamination in well 241-T-21, at the west edge of 200 West area. The gross mixture of the contaminants is moving eastward, however a small portion has evidently reached the crest of the ground water ridge between the T- and U-swamps, from which site it may eventually reach the river immediately upstream from 100-B area.

Redox Plant Sites

Well No.	Alpha Emitter Density 10^{-9} uc/cc			Beta-Gamma Emitter Density 10^{-8} uc/cc		
	March	February	January	March	February	January
241-S-6	2.18	0.57	4.84	55.5	9.08	15.8

Contamination of the ground water at this site may be from the 216-S (207-S) crib.

Sediment samples from the #9 and 10 wells (150 feet deep) at the 216-S crib show the following activity densities:

Well No.	Beta-Gamma Emitter Density 10^{-3} uc/g		
	March	February	January
9	6.63	4.78	11.6
10	--	2.5	5.9

LABORATORY EXPERIMENTS

Laboratory experiments dealing with the determination of the volumes of radioactive liquid wastes that can be safely discharged to ground without unduly contaminating the ground water with hazardous radioisotopes disclosed the following:

1. Adsorption of radioactive Sr from scavenged synthetic TBP wastes was found to be a direct function of the salt concentration over the range studied, as reported below, probably owing to the decreased flow rates and a corresponding increase in contact time as the molarity of the $NaNO_3$ increased. Soil column studies produced the following breakthrough data for the solutions, which had a pH of 9, a Sr activity density of 0.6 uc/ml and a PO_4^{-3} concentration of 0.1 M:

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$NaNO_3$ (molarity)	4	5	6	7
Breakthrough in Column Volumes	0.38	1.06	1.82	2.5
Flow rate, calculated as gal./sq.ft./day	>145	145	71	50

Results from more basic experiments, in which Sr was present in solutions containing $NaNO_3$ as the only significant salt, indicated a decreasing Sr adsorption with increasing $NaNO_3$ concentration. Equilibrium experiments were performed in these basic tests, and in them the contact time between soil and solution was constant. The experiments with the synthetic wastes used soil columns in which decreased flow rates resulted, with an increased contact time as the $NaNO_3$ concentration increased.

2. Breakthrough of Sr from scavenged synthetic TBP waste was inversely proportional to the Sr concentration over the range studied. The solutions, at pH 9, contained 4 M $NaNO_3$ and 0.1 and 0.2 M PO_4^{-3}. Inactive Sr was added to obtain the activity density desired and Sr^{89} was added in direct proportion to the inactive Sr. The following results were obtained for the two PO_4^{-3} concentrations and the four Sr activity densities noted:

Sr (uc/ml)		1.0	0.6	0.3	0.1
Column Volumes at Breakthrough	0.1 M PO_4^{-3}	0.5	1.4	2.8	>4
	0.2 M PO_4^{-3}	1.2	2.0	2.6	>4

3. The feasibility of combining the low PO_4^{-3}, scavenged TBP wastes with the reportedly high PO_4^{-3} scavenged first cycle wastes to achieve a product effecting greater Sr removal by soil was studied. Samples of the actual first cycle wastes from the 103-TY tank were mixed with samples of the scavenged TBP waste from the #2 107-BY tank and the #2 108-BY tank in the proportions of 1:2 and 1:3, respectively. The mixtures were percolated through soil columns. No appreciable increase in volume or total Sr adsorbed was noted over that encountered with the straight TBP wastes.

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Subsequent analysis of the scavenged first cycle waste indicated that the 103-TY sample contained only 0.2 M PO_4^{-3}, not appreciably higher than the PO_4^{-3} concentration of the TBP waste samples. Mixing of the two waste streams should be economically feasible, however, provided a PO_4^{-3} concentration of the first cycle waste sample is near an as yet undetermined optimum value.

4. Scavenged synthetic first cycle waste solutions were adjusted to various pH values and to various PO_4^{-3} concentrations. Solutions containing the equivalent of 2 uc Sr/ml and at pH of 7, 9, and 11, and containing 0.0, 0.001, 0.01, 0.025, 0.05, 0.1, and 0.25 M PO_4^{-3} concentrations resulted in no detectable breakthrough of Sr within 10 column volumes of solution, for the 21 combinations tested. No change in disposal recommendations is visualized for first cycle wastes having PO_4^{-3} and pH values within the limits tested.

DRILLING OPERATIONS

A total of 135 feet was drilled on the Earth Sciences FY 1955 program, and 282 feet on new facilities monitoring wells, by the two US Geological Survey drilling crews, as follows:

TABLE VIII

Well No.	Date Begun	Feet Drilled	Date Completed	Total Depth
Earth Sciences				
50-48	2-28-55	135'	Incomplete	
New Facilities (Purex)				
216-A-7-#18	3-7-55	150'	3-10-55	150'
216-A-5-#12	2-16-55	107'	3-1-55	343'
216-A-1-#5	2-3-54	25'	3-15-55	375'

Well number 50-48, about one-half mile north of the east edge of 200 East area, encountered basalt at a depth of 118 feet, an altitude of about 430 feet, or nearly 30 feet above the ground water table at this site, Basalt at this height and site,

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and at a height of about 10 feet above the water table in well 50-54, about one mile due west, indicates an east-west ridge rising above that water table and probably effectively deterring or blocking the northward movement of the ground water and contained contaminants from beneath 200 East area toward Gable Mountain and the Columbia River. Water, which was believed to be perched water, was encountered on the top of the basalt. Continued drilling and lowering of that water table tended to confirm that belief. Drilling continued to determine the exact regional ground water level at that site.

Well 216-A-1 #6 encountered basalt at a depth of about 370 feet, about 300 feet above sea level, appreciably below that encountered in well 50-48 and further demonstrating the presence of the basalt ridge noted above.

A total of 496 feet has been drilled to date on the Earth Sciences Fiscal Year 1955 drilling program. The originally requested ten wells totalling 3000 feet are to be supplemented by an additional 10 wells, totalling 2000 feet, approval for which was granted in March, 1955. Expansion of the drilling program is clearly required, to obtain information in sites near the 200 East area where high ground water velocities are indicated.

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